

Encl #1
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COPY 1 OF 1

"C" Conf

PROPOSED EVALUATION PROGRAM

FOR

HR-73C CONFIGURATION

ENGINEERING REPORT NO. 5232

DATE: 11 April 1958

PROJECT MANAGER:

[Redacted]

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I INTRODUCTION

This report explains the proposed evaluation program for the HR-73C Configuration System.

A brief description of the Configuration is included, as are sections on performance and vibration. It is felt that the considerations discussed in these first sections logically suggest the implementation of the proposed program. Furthermore, it appears that the proposed program has a very high probability of success.

II DESCRIPTION

The HR-73C Configuration System is a 180-inch focal length, f/13.8, 13-inch by 13-inch format, high-altitude spotting camera for detailed small-area reconnaissance. It carries two rolls of film, each 6-3/4 inches wide by 4,000 feet long, which run side by side in opposite directions across the format. The camera employs an angle of view for a single exposure of 4-1/2 degrees, but can scan through an infinite number of oblique positions from 60 degrees left to 60 degrees right of the line of flight.

In vertical, or in any oblique viewing angle within the limits of the system, three modes of operation are available which may be selected and/or changed in flight. Mode 1 provides an eight-exposure burst pattern consisting of four stereo pairs, two side-by-side, two in line. Mode 2 provides a continuous single-line pattern along the flightline with 55% minimum of overlap of frames. Mode 3 provides a continuous double-line pattern along the flightline with 10% minimum overlap and side lap. The camera is remotely controlled and is fully automatic in its operation once the mode has been selected and the target determined. Mode selection and target identification are accomplished by means of a hand-control and driftsight located in the pilot's cockpit. In the aircraft, the camera is so mounted that during photographic operation it is stabilized independently of the aircraft. At all other times the camera is caged and securely locked to the airframe. The stabilizer system also provides the proper DMC action during photographic operation.

III PERFORMANCE

SPECIFICATION

"The criteria for design is approximately 60 lines per millimeter resolution under good operating conditions. It is expected that better than 40 lines per millimeter will be achieved considering the low contrast targets and other degradations of the image encountered in actual operations."

ACTUAL PERFORMANCE

Two systems are currently in operation. The first system produced 32 lines per millimeter visually in the optical shop, but without a bend in the Field and Projection Groups and 11 lines per millimeter photographically. In January 1957, its first flight yielded 5-6 lines per millimeter. After improved focus, temperature control, and some initial vibration control this first system again measured 32 lines per millimeter visually and 17 lines per millimeter photographically at "H". In August 1957 a flight test gave approximately 10 lines per millimeter. With some additional vibration control the flight test of 10 March 1958 yielded approximately 12-13 lines per millimeter. However, it is known that this first system used in this flight test requires optical re-alignment and consequently this system will undoubtedly provide better performance.

The second system produced visual resolution of 40 lines per millimeter in the optical shop. On 7 April 1958 the second optical system easily resolved 33 lines per millimeter photographically at this facility (see appendix).

A third optical system gave 60 lines per millimeter visually in the optical shop, but a triplet in the Projection Group now requires rebonding.

ACHIEVABLE PERFORMANCE

Preliminary measurements made by the Vibration Consultants (and measurements reported by "H") indicate that optical components are vibrating greatly beyond allowable limits if 60 lines per millimeter resolution is to be achieved. Making 60 lines per millimeter the design objective (although not the limit)

for vibration control, degradation of the image due to vibration will surely be lessened. While it is impossible to make an unqualified statement as to the improvement in resolution that will result from reduced vibration, it seems reasonable to assume that half of the resolution degradation caused by vibration can be eliminated.

In the case of the first system (the system which gave 32 lines per millimeter visually), there is a loss of about 20 lines per millimeter. Assuming arbitrarily that half of the loss results from optical causes and half from vibration causes, it could be assumed that the optical causes (other than atmosphere) can be eliminated and the vibration causes halved, resulting in a resolution of about 25 lines per millimeter.

The second system (40 lines per millimeter visually) would be expected to yield 30 lines per millimeter by similar reasoning. Extending this relationship, a system yielding 60 lines per millimeter visually might be capable of 45 lines per millimeter in actual operation.

There is, obviously, a degree of speculation in this estimate of achievable performance. The principal objective of the proposed evaluation program is to reduce the speculation regarding achievable performance.

IV VIBRATION

SENSITIVITY

It is important to recognize that vibration of a motor, or gear, or any other non-optical part is of no importance except to the extent that it may cause an optical part to vibrate excessively. That is, degradation of the optical image can be caused only by vibration of optical components. ^{?? PACKAGE VS UNITS IN the package}

The various optical elements are subject to several modes of vibration. However, the photographic results of flight tests show image doubling to be the most significant degradation of quality. Image doubling can be caused only by certain modes of vibration, but the various vibrations of each element are not equally harmful. Therefore, the relative sensitivity of each element to image doubling vibrations has been computed. (See Table 1).

VIBRATION SOURCES

Vibrations of optical components are potentially caused by many other components. The vibration sources can be divided as follows: (1) Internal steady-state vibrations; (2) external steady-state vibrations; and (3) internal transient vibrations. (See Figure 1.)

Furthermore, the vibrations may excite resonant vibrations in the optical elements, or, conversely, may be attenuated or of an amplitude and frequency that cause no difficulty.

ANALYSIS

The problem of vibration analysis is extremely complex. In practical terms, the best approach is to measure frequencies and amplitudes of many components of the system. These measurements should be made under conditions most nearly approximating operational environment.

After measurements are made, a "worry factor" can be assigned to each optical element. This factor can be considered as the product of vibration magnitude and element sensitivity. That is, a sensitive element that experiences a large

VIBRATION MODE ELEMENT	ROTATION SENSITIVITY	TRANSLATION	
		DIRECTION	SENSITIVITY
SCAN	30	—	—
PRIMARY	30	PERPENDICULAR TO OPTIC AXIS	3
ELEW	6	PERPENDICULAR TO SURFACE	5
G	12	PERPENDICULAR TO SURFACE	1
H	6	PERPENDICULAR TO SURFACE	1
I	3	PERPENDICULAR TO SURFACE	1
PLATEN	—	PERPENDICULAR TO OPTIC AXIS	0.7

Table 1: Relative sensitivity to vibrations causing image doubling (Arbitrary Units- higher number indicates greater sensitivity).

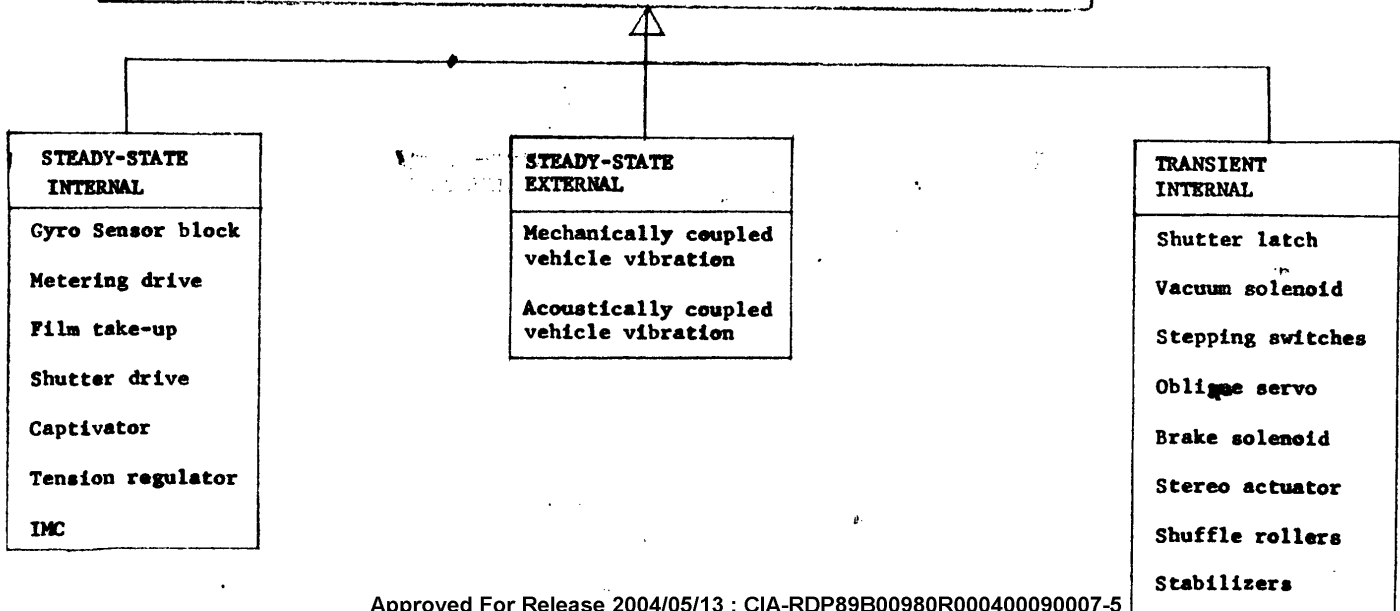
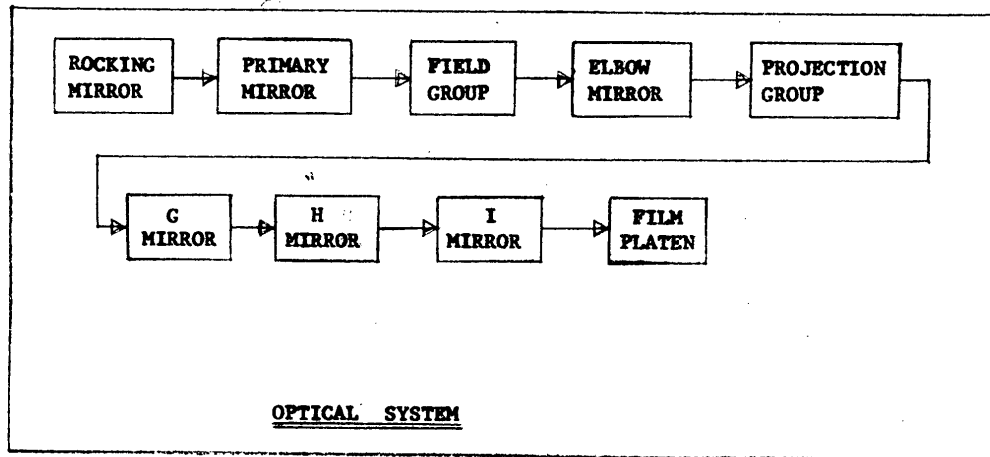


FIGURE 1: VIBRATION SOURCES

vibration will be a very serious cause of image degradation, and elements with a high "worry factor" can be investigated first.

V PROPOSED PROGRAM

GENERAL

The basic program is for a logical, scientific investigation of the "C" System leading to a sound evaluation of its ultimate capabilities. Necessarily, however, there are "housekeeping items" such as organization and orientation of personnel and installation of the "C" system. But, it is primarily desired to eliminate (or greatly reduce) the speculation about the "C" System's performance.

Basically, this can be accomplished by: Firstly determining which optical components are degrading the image; secondly determining what is causing those optical components to vibrate; thirdly determining how to eliminate these causes of vibration; and fourthly determining how much improvement can be expected by elimination of the vibration causes.

SCHEDULE

The evaluation is scheduled to be completed by 15 May 1958. This is a "tight" schedule, but not unrealistic. To date, several items have been completed and there still appears to be adequate time to complete the remaining portion of the evaluation on schedule. (See Table 2.)

ESTIMATED SUCCESS

Upon completion, this proposed evaluation program will obviously permit an intelligent estimate of the "C" System's ultimate performance. Furthermore, the work completed to date indicates that there is every reason to be optimistic about achieving higher resolution after modifications to the "C" System.

ITEM	STATUS
Establish organization	Complete (see figure 2).
Install "C" System	Complete
Install 300" Collimator	Complete
Orient personnel	Complete
Contract vibration consultants	Complete
Preliminary analysis	Complete
Measure vibrations of components	Complete
Ascertain sources of vibrations	Due by 25 Apr. '58
Determine how to eliminate vibrations	Due by 9 May '58
Determine potential improvement	Due by 15 May '58

Table 2: Evaluation Program and Schedule

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VI APPENDIX

PHOTOGRAPHIC TEST OF 7 APRIL 1958

Optics: Second System (40 l/mm visually)

Configuration: No. 4

Arrangement: Configuration caged, shutter removed, all power off;
mounted in heavy stand on heavy frame with vibration isolation
between stand and frame, and between frame and floor; 300"

Collimator on floor under scanning flat.

Source: 3, 5, 10 and 20 line per millimeter resolution charts in
Collimator

Film: Kodak Spectroscopic Plate, Type V-F

Results: All targets resolved (5, 8, 16 and 33 lines per millimeter,
respectively, at platen); and it seems that 40 lines per millimeter
could have been resolved if an appropriate source was available.